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## Performance Analysis of ALOHA Framework under Limited Access of Data Transmission for Active RFID System

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### Abstract

The data collision of multiple tags to access the channel is one of the most problems in active Radio Frequency Identification (RFID). The technique of random tag is based on William Feller equation by considering the successful probability ( $P_{suc}$ ) may affect to increase the data collision if the tag is not limited the privilege. This paper proposes the modification of William Feller equation by dividing the privilege of tags into several groups. The results show that our scheme can provide the better performances as comparing with William Feller equation in term of successful probability. The maximum average of successful probability is more than 0.97.

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**Keywords:** active RFID, Slot, William Feller

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### 1. Introduction

Radio Frequency Identification (RFID) [1] is the object identification system by using the radio frequency for the communication between the transmitter and receiver. In this system, the object surface is holded on the tag to communicate with the reader of RFID if the tag is in the radius of the radio frequency. Then, the data of tag will be record. Generally, There is one of the most problems of RFID if we have multiple tags access to a reader as the same time. The data collision can be occurred. Therefore, several researchers have been proposed the protocol in order to avoid the data collisions. The ALOHA algorithm [2] is a basically method that prevents the collision of data based on Time Division Multiple Access (TDMA). There are three flavors of original ALOHA algorithm such as ALOHA, Slotted ALOHA [3] and Frame Slotted ALOHA [4]. Frame Slotted ALOHA (ISO/IEC1800-7)[5] is one protocol that developed from ALOHA. This method considers the concept of time division of sending tag for each frame called time slot and uses the random technique for accessing the slot of each frame. Usually, the random

technique by the probability equation analysis of William Feller (Psuc) is a well-know technique which uses the tag to access the time slot of one frame only. In this concept, the collision of data may be increased due to the several tags may access the time slot as the same time, there are the chance of the collision.

In this paper, we present the concept of considering the frame slot into 2 sets and limiting the privilege to access the tag in the slot into 2sets. The first set is the random for accessing overall slots and the second set is the random access for only half slot of frame. Both sets will consider the probability of sending success data based on William Feller and the both sets can random the tag with the different size freely by considering the performance analysis of each size of each frame and to find the appropriate of frame for transmitting the data of active RFID. This technique may improve the better performance of accessing the time slot of active RFID.

## 2. William Feller Equation Analysis

In order to analyze the probability of William Feller equation, we consider the successful probability. We suppose that  $P$  means the probability of sending data successfully in case of solving the collision in system and  $C$  that means the probability of event.  $M$  is the slot while sending the data successfully and  $V$  that means the slot of sending the request. The probability of transmitting success data can be expressed as

$$P_s(c|m, V) = \frac{(-1)^c V! m!}{V^m c!} \sum_{j=c}^{\min(m, V)} \frac{(-1)^j (V-j)^{m-j}}{(j-c)!(m-j)!(V-j)!} \quad (1)$$

where  $0 \leq c \leq \min(m, V)$

We consider the probability of  $P_m(m)$  from the slot  $n$  to  $m$  as sending the request to continue

$$P_m(m) = \binom{n}{m} p^m (1-p)^{n-m} \quad (2)$$

Where  $S(n, m)$  is the request for accessing the slot in case of transmitting data

$$S(m, V) = J \cdot \sum_{c=1}^{\min(m, V)} c \cdot P_s(c|m, V) \quad (3)$$

group will access the slot more than the second group approximately 2 or it can access random slot between 1 slot to slot of  $\frac{3}{2M}$

We can compute the probability by given

$$P\left\{a_1, a_2, \dots, \frac{a_{2M}}{3}\right\} = \frac{(N/2)!}{a_1! a_2! \dots a_{\frac{2M}{3}}!} \cdot \frac{(2M/3)!}{b_1! b_2! \dots b_{\frac{2M}{3}}!} p^{a_1} p^{a_2} \dots p^{\frac{a_{2M}}{3}} \quad (4)$$

Where  $p(a_i)$  of this group has the value equal  $\frac{3}{2M}$ . Thus,  $p^{a_1} p^{a_2} \dots p^{\frac{a_{2M}}{3}}$  can be obtained the value of  $(\frac{3}{2M})^{N/2}$ . The second group can random the slot of  $\frac{2M}{3}+1$  until to  $M$  slot, the calculation of probability is given by

$$P\left\{a_{\frac{2M}{3}+1}, a_{\frac{2M}{3}+2}, \dots, a_M\right\} = \frac{(N/2)!}{a_{\frac{2M}{3}+1}! a_{\frac{2M}{3}+2}! \dots a_M!} \cdot \frac{(M - \frac{2M}{3})!}{b_{\frac{2M}{3}+1}! b_{\frac{2M}{3}+2}! \dots b_M!} p^{\frac{a_{2M}{3}+1}} p^{\frac{a_{2M}{3}+2}} \dots p^{a_M} \quad (5)$$

Where  $p(a_i)$  of this group has the value of  $\frac{3}{M}$ . Therefore,  $p^{\frac{a_{2M}{3}+1}} p^{\frac{a_{2M}{3}+2}} \dots p^{a_M}$  can be obtained by  $(\frac{3}{M})^{N/2}$

## 3. Performance Analysis

The system analysis based on the equation of William Feller must use the overall events, the random slot of tag to calculate and it consists of the procedure of selecting the event in order to avoid the duplicate events as shown in Fig. 1. As we can get the value of accessing the slot of a and b, we should summarize all the values in one frame by defining the slot equal zero for calculation the probability of sending success data in one frame. The probability must not over one and it should repeat every frame for the comparison.

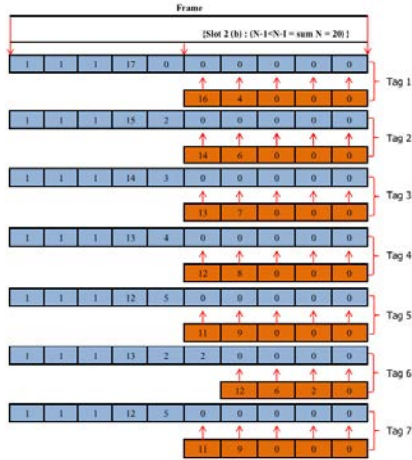


Fig. 1 The slot tag access for summation the a and b frames.

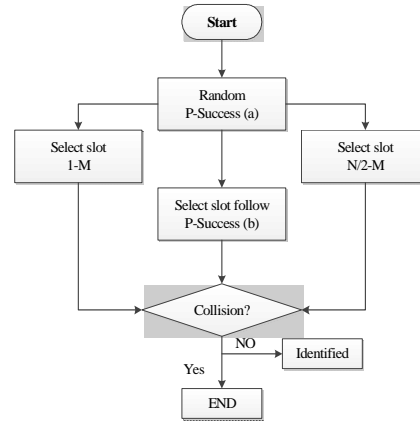


Fig. 2 The procedure of accessing the slot of two frames

#### 4. The Format of Analysis the Numerical

The probability of each slot according to the condition is based on the mathematic for calculation the successful of accessing slot in RFID. For the analysis, we assign the  $N$  tag to access  $M$  slot and divide  $M$  into many parts by using the equation of selecting the slot. The probability of  $N$  tag that accesses the arbitrary slot can be obtained by

$$\frac{N!}{a_1! a_2! \dots a_M!} \quad (6)$$

Where  $a_1!, a_2!, \dots, a_M!$  are the number of tags in each slot form 1 slot to  $M$  slots. The probability of  $M$  slots will hold by tags. This means that the probability of  $M$  slots have been occupied by the arbitrary tags as

$$\frac{M!}{b_1! b_2! \dots b_M!} \quad (7)$$

Where  $b_1!, b_2!, \dots, b_M!$  are the numbers of slots which have the number of similarity tags in each slot such as the number of tag equal one, we can get the value from equation 1), (2) as  $N$  is the number of tags in the system and  $M$  is the number of slots in one frame. We can compute the probability of event in each frame as follows:

$$P\{a_1, a_2, \dots, a_M\} = \frac{N!}{a_1! a_2! \dots a_M!} \frac{M!}{b_1! b_2! \dots b_M!} P_1, P_2, \dots, P_N \quad (8)$$

Where  $P_1, P_2, \dots, P_N$  are the probabilities of each slot which considers as sending data successfully. This means that the number of tags as accessing 1 slot to  $i$  slot equal one, i.e.,  $a_1 = a_2 = \dots a_i = 1$  For the other slots, the values are not one such as  $a_{i+1} = a_{i+2} = \dots a_M \neq 1$  Thus, the success probability of  $P_{suc}$  is the summation of  $P\{a_1, a_2, \dots, a_M\}$

#### Proposed Method

Our proposed method, we consider the probability of William Feller to analysis which uses every event of accessing slot or accessing the random of tag for calculation. The procedure of selecting the record of each event to protect the duplicate events, we divide the slot for accessing tag and divide the privilege to access according to the condition and assign the events as shown in Fig.2.

#### Experiment and Results

In the system analysis, we consider the probability analysis by using the formula of William Feller for random the tag for avoiding the collision. In this paper, we focus on the comparison of our method with William Feller formula (limit the privilege of tag and non-limit the privilege of tag) to access the slot of active RFID. The purpose of our experiment is to consider the success probability based on several conditions like the various tag and fixed the frame size and so on.

The first experiment result is shown in Fig. 3. We have fixed the frame size and various the number of tag ( $N$ ) and the

number of slot ( $i$ ) in the system by considering the success probability. The results show that our method (normal lines) has the results consequently with the method of William Feller (dash lines). We observe that the number of high tags ( $N=60(2G)$ ,  $N=50(2G)$ ,  $N=40(2G)$ ) will be increased the success probability ( $P_{suc}$ ) respectively as the number of slots are less. But the number of slots is increased, the total results will be opposite. The success probability will be achieved as  $N=40(2G)$ ,  $N=50(2G)$  and  $N=60(2G)$  respectively. This means that the increasing of slot numbers may provide the increasing of the collisions in the system, the success probability will be decreased. However, our results can provide the maximum average of success probability approximately 0.98 that more than the method of William Feller.

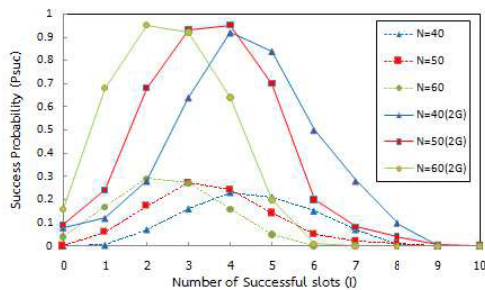


Fig. 3 The comparison of success probability between the accessing non-privilege tag and privilege tag

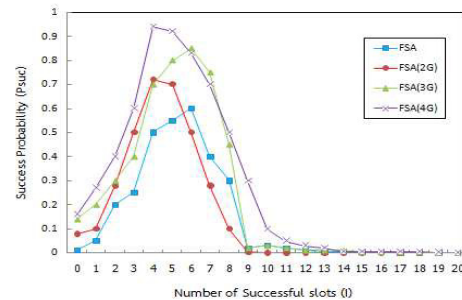


Fig. 4. The probability of sending success probability in system as fixed the tag of 60 tags and the frame slot equal 20 slots

In Fig. 4, we define the parameter of experiment by using the frame size is less than the number of tags (20 slots and 60 tags) and varying the group of accessing the privilege of tag into 2, 3 and 4 groups respectively including various the number of slot ( $i$ ) to analysis the success probability in the system. We compare our method with William Feller formula. The results show that our scheme (FSA(2G), FSA(3G) and FSA(4G)) can provide the highest success probability as comparing with William Feller formula which is non-limited the privilege of tag (FSA). The maximum average of success probability is 0.97. We observe that the success probability will be highest achieved as limited the privilege of tag into FSA(4G), FSA(3G) and FSA(2G) respectively. However, if the number of slots is increased, the success probability will be decreased but our scheme can provide the better performance more than that of non-limited the privilege of tag.

## 5. Conclusion

This paper presents the performance analysis of accessing the tag of Frame Slotted ALOHA based on limited the privilege of tag in active RFID system by comparing with the method of William Feller. In this concept, we consider the probability of accessing successful tag based on the different of privilege tag. The results show that our scheme can provide the better performances in terms of the successful probability more than the method of William Feller which has not limited the privilege of tag.

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